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A PRELIMINARY STUDY OF SLANT RANGE ESTIMATION FOR OBSERVERS ON ELEVATED PLATFORMS

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A PRELIMINARY STUDY
OF SLANT RANGE ESTIMATION
FOR OBSERVERS ON ELEVATED PLATFORMS

By

CHARLES FRIED

Technical Assistance of James A. Meadows

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APPROVED: John D. Weisz
JOHN D. WEISZ
Director
Human Engineering Laboratories

ABSTRACT

A preliminary investigation of aerial estimation of slant range-to-ground targets was conducted on fixed platforms of approximately 25.5, 71, and 105-foot elevations.

In addition to the three altitudes, the study compares the effects of increasing observation time from 10 to 20 seconds and extending the ground range of targets from 50 to 1,102 yards.

No improvement in performance resulted from increasing observation time from 10 to 20 seconds. It is suggested that time intervals of less than 10 seconds be considered for further investigation.

A slight but noticeable underestimation of range occurs for the lower altitudes for the shorter ground ranges. This effect drops out at increased altitudes and ranges. For intermediate ranges of 100 - 800 yards, the lower altitude of observation proved superior. However, at the range of 800 to 1,100 yards, increasing the observer's altitude improved performance.

The amount of slant range estimation error is approximately a linear function of ground range. For ranges greater than 250 yards, it is in the neighborhood of 60 to 75% of ground range.

A PRELIMINARY STUDY OF SLANT RANGE ESTIMATION FOR OBSERVERS ON ELEVATED PLATFORMS

INTRODUCTION

The proposed placement of ground target weapons on low level aerial platforms, as helicopters, places a requirement for accurate slant range estimation upon a pilot or observer-gunner located on the platform.

A number of mechanical and electrical aids to range estimation have been proposed for helicopter use. To form a baseline against which these suggested aids may be compared, this study proposes to investigate the capabilities of unaided, untrained observers in estimating slant range.

In the present study, a fixed elevated platform was utilized. Future studies in this series will utilize military helicopters as the elevated platform. The helicopters in these studies will employ such typical maneuvers as pop-up, continuous or irregular forward motion, etc.

The subjects for the study consisted of an average selection of enlisted men stationed at an Ordnance installation. It may be predicted that improved ranging would occur with more highly selected subjects. Since naive subjects were used throughout the study, these results can also be used as a base against which the success of a training program could be compared.

METHOD AND PROCEDURE

A total of 22 enlisted men stationed at Aberdeen Proving Ground were brought to the Madonna Fire Tower located at Madonna, Maryland,* in groups of three and four (Fig. 1). This area was selected for its proximity to Aberdeen Proving Ground and for its relatively flat and unobstructed view of the surrounding terrain. Targets could be positioned up to a range of approximately 1,100 yards and still be visible.

The targets consisted of wooden frames of rectangular shape (4 by 6 feet), covered by a cloth fiber that had been dyed yellow (Fig. 2). This easily observable color was chosen in order to make the task of finding the target as simple as possible. Since time to range was one of the independent variables for estimation of range, it was desirable that the time required to explore the surrounding field, not influence the obtained results.

* The Human Engineering Laboratories wishes to express its appreciation to the Maryland State Dept. of Forests and Parks for permission to use their facilities at Madonna.

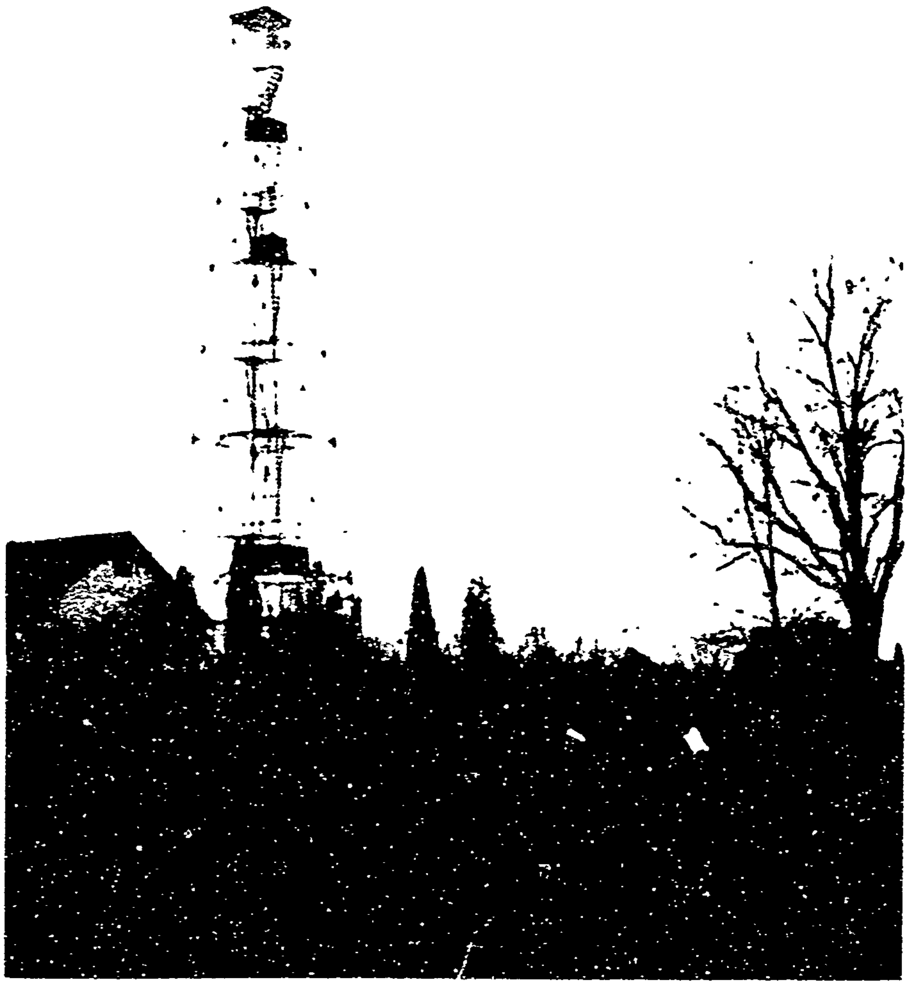


Fig. 1 - MADONNA FIRE TOWER. Observations were made from the platforms on which canvas guards have been built.

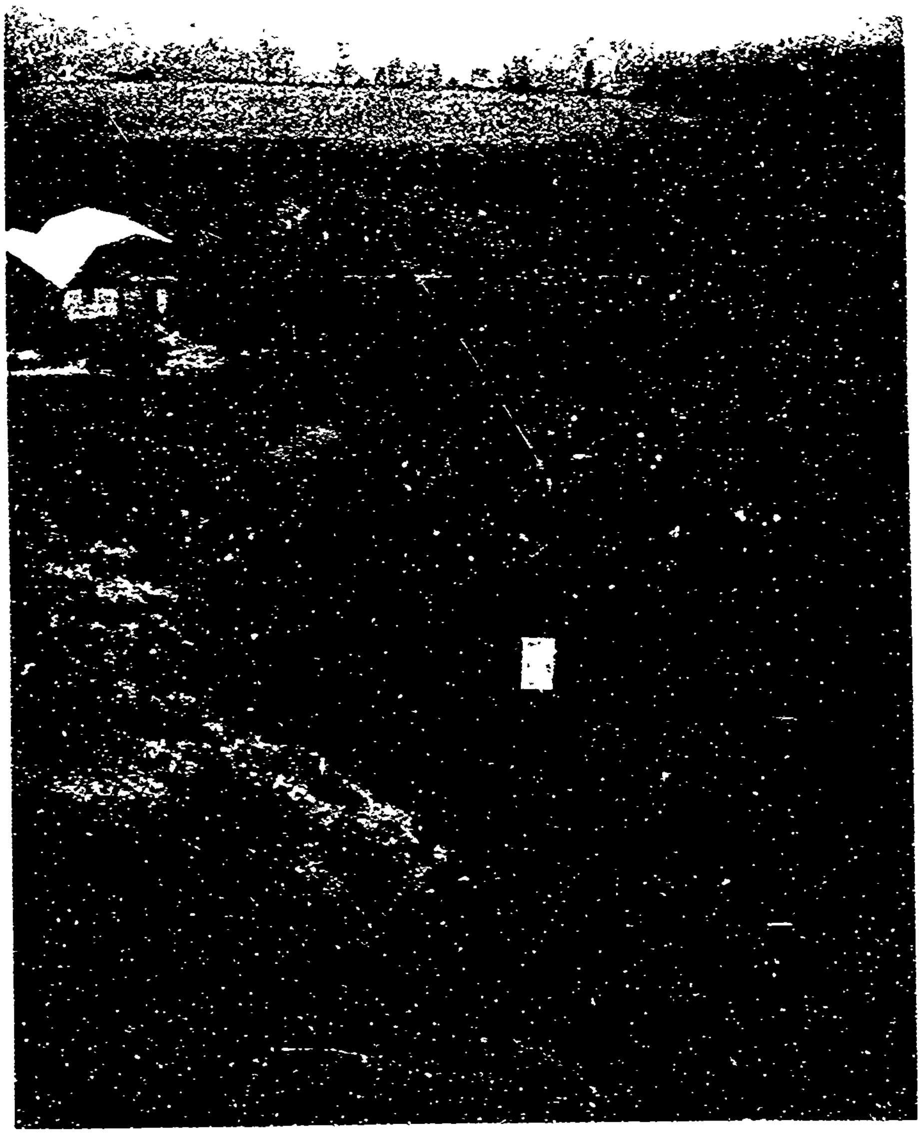


Fig. 2 - View of surrounding terrain with one target raised, as seen from the Madonna Fire Tower.

Nine fixed positions in the field surrounding the fire tower were used for target positions. These were numbered in the following manner:

Target	Distance from Target
1	50 yards
2	75 yards
3	100 yards
4	200 yards
5	300 yards
6	350 yards
7	502 yards
8	702 yards
9	1,102 yards

An enlisted man was stationed near each of the targets and upon a signal from a walkie-talkie would raise the target and keep it raised until told to lower it.

The subjects were given instructions at the base of the tower before going up to their first position, as follows:

> "In this study, we are interested in how accurately you can estimate slant range (explain) to a target from a particular height.
>
> "The target will be the yellow rectangle held up by a soldier in the field. You are to judge its distance, in yards, from where you stand in the tower. You will be allowed only one estimate and a short period of time to make it in. Go up to the platform that the experimenter tells you to without looking at the target and then face away from it, when you reach the platform.
>
> "The experimenter will signal you when you are to face the targe and when you are to look away from it. Use all the time alloted for your estimate."

They were not informed at any time during the study as to whether they had made an accurate estimate or the extent of their error.

The subjects were instructed to go to one of three platforms (Fig. 1) in the tower and face away from the targets. After the experimenter (E) had signaled by radio to the assistant in the field to raise a designated target, the subject (S) was told to get ready to make his estimate. Upon the signal, "go", the S would turn around to face the raised target, and the E would start a stop watch. Upon the completion of either a 10- or 20-second time period, the E would say, "Stop - now turn around", and the S would then indicate to the E his estimate of slant range (Fig. 3). The next S would then come up to the same platform and the procedure would be repeated.

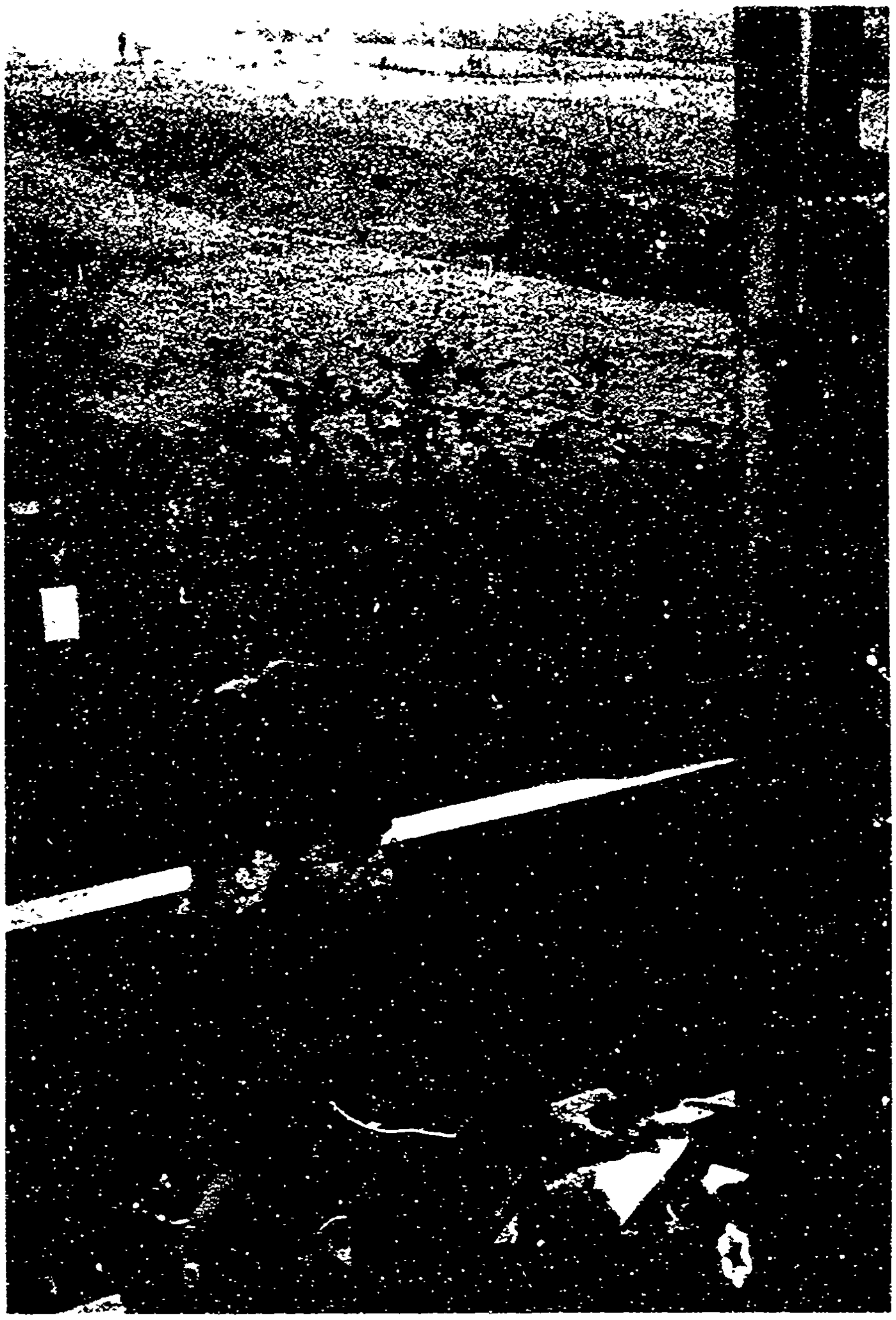


Fig. 3 - Subject And An Experimenter Recording Range Estimation

After a block of four subjects had been exposed to a target at a particular height, they would proceed to the next altitude desi·· ated by the E and the procedure, described above, would be repeated.

The three platforms used were at 25.5, 71, and 105 feet. The correct slant ranges are listed in Table 1.

Table 1

Actual Slant Range to Targets

From The Three Tower Altitudes (In Yards)

Position	Ground Range Yards	Tower Heights (In Feet) 25.5'	71'	105'
1	50	51	55	61
2	75	75	79	83
3	100	100	103	106
4	200	200	201	203
5	300	300	301	302
6	350	350	351	352
7	502	502	503	503
8	702	702	702	703
9	1102	1102	1102	1103

The sequence of targets and platform heights was varied randomly in order to prevent any of the altitudes or ranges from being systematically affected by fatigue or training.

Range estimates were limited to days on which the minimum visibility would include the targets' positions at the maximum distance of 1,100 yards (Table 2).

Table 2

Description of Weather During Study

Date	Visibility	Temp.	Description
8 Nov	7 Miles	60°	Ptl. Cloudy
15 Nov	5-6 Miles	65°	Ptl. Cloudy and Windy
17 Nov	Unlimited	70°	Clear and Sunny
18 Nov	6 Miles	60°	Ptl. Cloudy
21 Nov	6 Miles	60°	Ptl. Cloudy
22 Nov	5-6 Miles	65°	Ptl. Cloudy

SUBJECTS

Twenty-two enlisted men attached to the USA Ordnance Special Troops Battalion, Aberdeen Proving Ground, Maryland, were assigned as Ss for the study. Their ages ranged from 17 to 30. None of the Ss had any prior experience in aerial or ground-range estimation. Orthorater tests for far visual acuity were given and the results presented in Table 3. A score of 10 on the Orthorater is equivalent to 20/20 on the Snelling Chart. The narrow range of scores was probably the result of the subjects being permitted to wear their glasses during the test.

Table 3

Median Orthorater Scores for Far Visual Acuity

	Median	Q
Far Visual Acuity - Both Eyes	11.75	.57
Far Visual Acuity - Left Eye	10.50	.10
Far Visual Acuity - Right Eye	11.30	.05

RESULTS

Three independent variables were investigated: (1) The amount of time the S was allowed to make the range estimation. The two time intervals used were 10 and 20 seconds (a third period of 30 seconds was included in a pilot study, but the results were almost identical with those recorded for the 20-second interval). (2) The three altitudes from which the targets were positioned.

Table 4 presents results for mean error in yards of slant-range estimation for the independent variables of time, altitude, and range. A positive value indicates an overestimation of range and a negative value an underestimation of range.

These results are graphed in Figs. 4, 5, 6, 7, 8, and 9. Figs. 4, 5, and 6 present the mean-slant range error for ground range and time to observe for each of the three altitudes. Figs. 7, 8, and 9 present the mean slant-range error for the ground range and altitude for the two time intervals of 10 and 20 seconds, and the two time periods combined.

Characteristically, the ranging error is slight for the nearer ranges and then rises steadily in an approximately linear fashion.

The most significant finding for Figs. 4, 5, and 6 is the degree of overlap in errors of estimation for the 10- and 20-second periods of observations. This confirms the reports of the subjects in the field that a range estimate or fix is made almost immediately after a target is first seen. In addition, the findings of the pilot study, which included a 30-second interval, indicated that little or no improvement occured as observation time increased from 20 to 30 seconds.

Whether range estimation accuracy will decrease if time to observe is reduced below 10 seconds, will have to be investigated in future studies in this series. It seems that no improvement in range accuracy is gained by increasing the observation time above 10 seconds. This result applies only to range estimation and should not be extended to such additional tasks, of an aerial observer, as location and identification of a target.

A single exception to this finding is the range estimation for the target location at the ranges of 1,100 yards, for the lowest altitude of 25 feet. A sizable improvement in range estimation occurs as the time to observe is increased from 10 to 20 seconds.

This last result is probably due to the added time required to find the target at this great range. Targets at distances greater than 1,100 yards were included in the pilot study, but Ss either were unable to locate them or spent an inordinate amount of time searching for the targets.

The effect of increasing altitude on range estimation is somewhat more difficult to interpret. The slight underestimation of range for the shorter ranges drops off as the altitude is increased. If we consider range estimation from a ground position as a limiting condition of the effect of altitude on range estimation, it has been a frequently confirmed finding that observers consistently underestimate ranges up to about 100 yards. For distances greater than 100 yards, the error for all altitudes is positive or an overestimation of range.

From about 100 to 700 yards, there is an irregular but consistent trend for estimation accuracy to drop as altitude is increased, i.e., the performance is best from the 25.5 foot altitude and poorest for the 105-foot altitude, with the estimations from the 71-foot platform falling roughly midway between those two values.

At the maximum range of 1,100 yards, there is a slight tendency for the higher altitudes to result in improved ranging. This finding would suggest that for ranges greater than 800 to 1,00 yards improvement in ranging may result by increasing the altitude of observation, for ranges less than this the lower altitude of 25.5-feet is recommended.

The effect of increased range on range estimation is very roughly a linear function, with the exception of ground ranges below 250 yards. The absolute error is in the neighborhood of 60 - 75% of ground range. This extremely large error may be attributed to the inexperience of the Ss. Specially selected and trained observers would undoubtedly perform more efficiently.

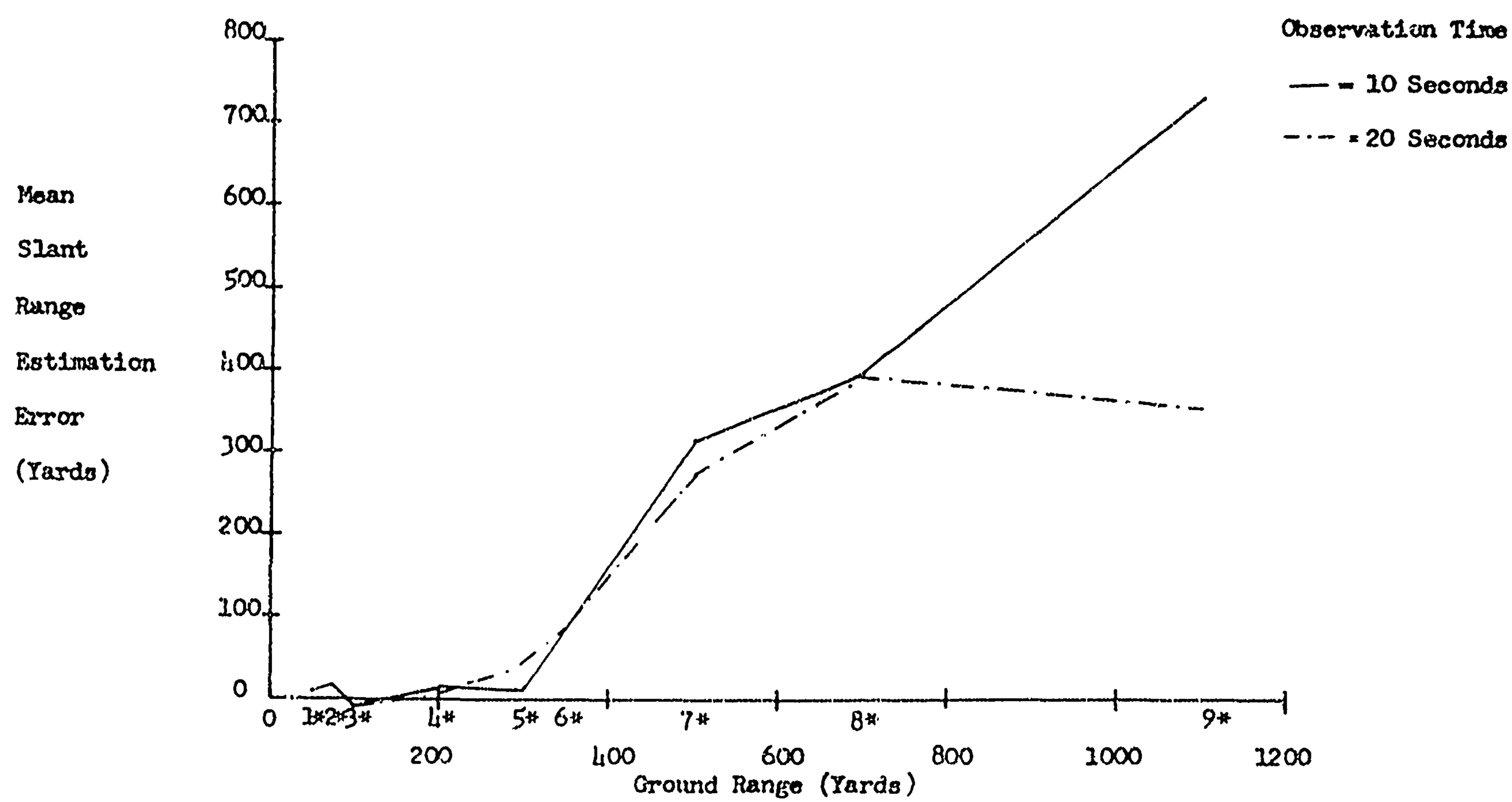
Table 4

Mean Slant-Range Estimation Error for Target (In Yards)

For Position, Altitude of Observer, and Time of Observation

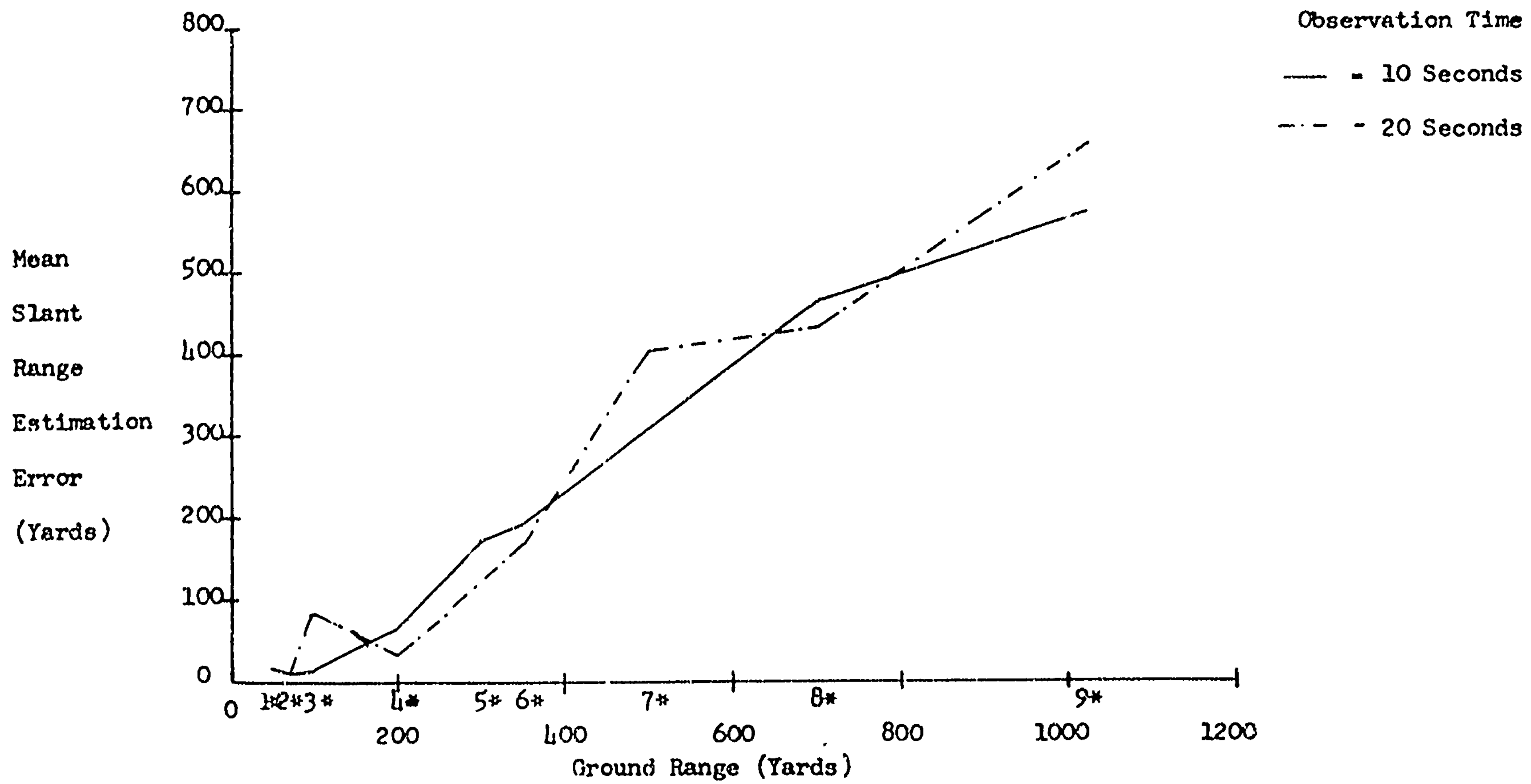
Target Position	Altitude	10 Second Observation	Target Position	Altitude	10 Second Observation	Target Position	Altitude	10 Second Observation
1		1.68	1		19.67	1		23.65
2		17.25	2		9.94	2		18.37
3		-5.04	3		19.50	3		9.28
4	25.5	15.04	4	71	65.40	4	105	97.59
5		6.68	5		178.84	5		124.26
6	feet	84.31	6	feet	192.42	6	feet	188.49
7		316.45	7		313.34	7		437.73
8		399.31	8		463.20	8		486.17
9		730.95	9		578.87	9		554.25

Target Position	Altitude	20 Second Observation	Target Position	Altitude	20 Second Observation	Target Position	Altitude	20 Second Observation
1		3.54	1		15.12	1		25.47
2		-8.77	2		17.52	2		14.51
3		-4.54	3		85.63	3		35.37
4	25.5	11.72	4	71	28.10	4	105	93.09
5		45.00	5		167.75	5		94.42
6	feet	90.45	6	feet	162.60	6	feet	135.29
7		268.68	7		400.29	7		594.50
8		396.80	8		429.65	8		494.81
9		349.61	9		653.58	9		485.07



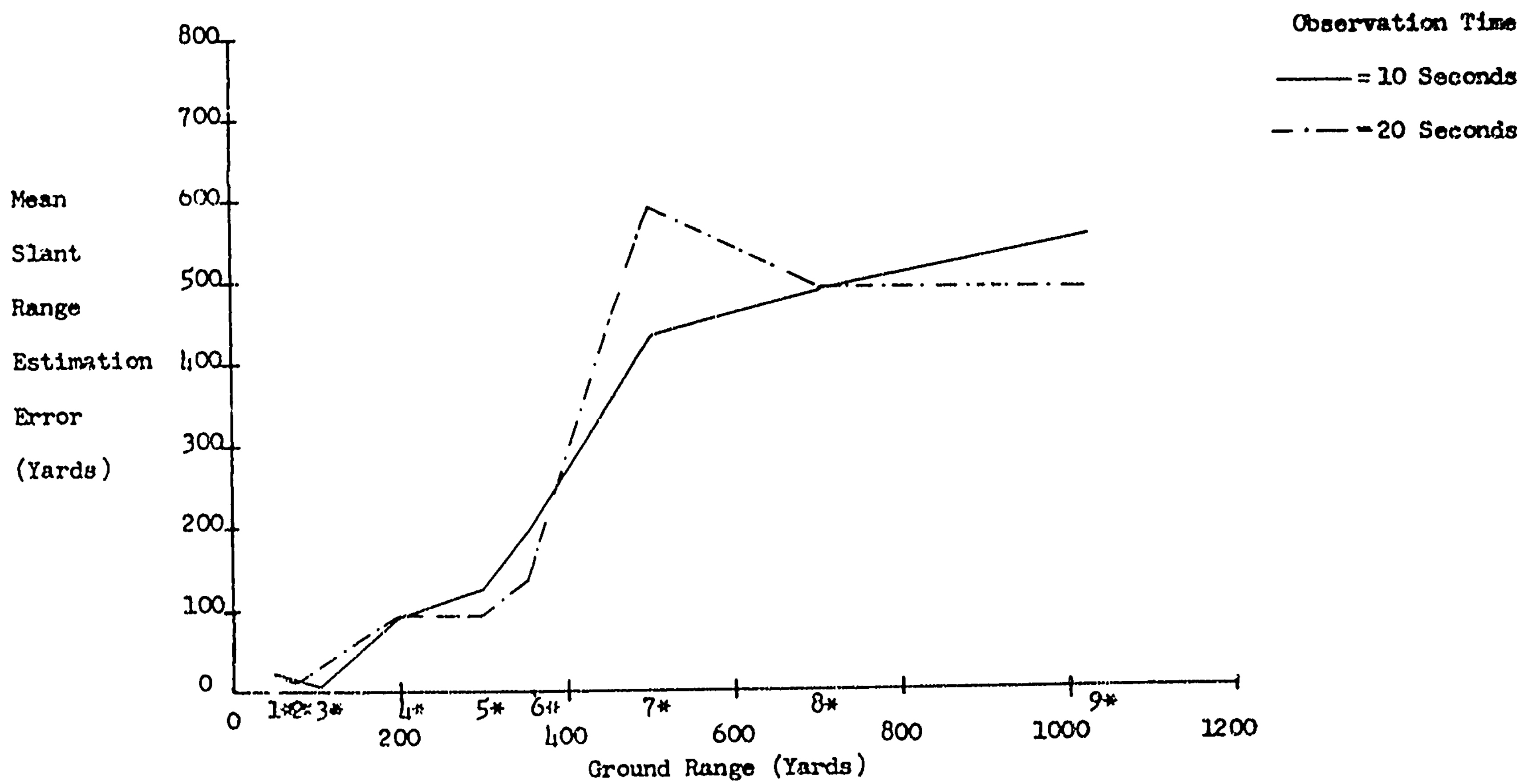
* Numbers Refer To Positions Of Targets Relative To The Fire Tower

Fig. 4 - Mean Slant-Range Estimation Error From A Fixed Altitude Of 25.5 Feet



* Numbers Refer To Positions Of Targets Relative To The Fire Tower

Fig. 5 - Mean Slant Range Estimation Error From A Fixed Altitude Of 71 Feet



* Numbers Refer To Positions Of Targets Relative To The Fire Tower

Fig. 6 - Mean Slant Range Estimation Error From A Fixed Altitude Of 105 Feet

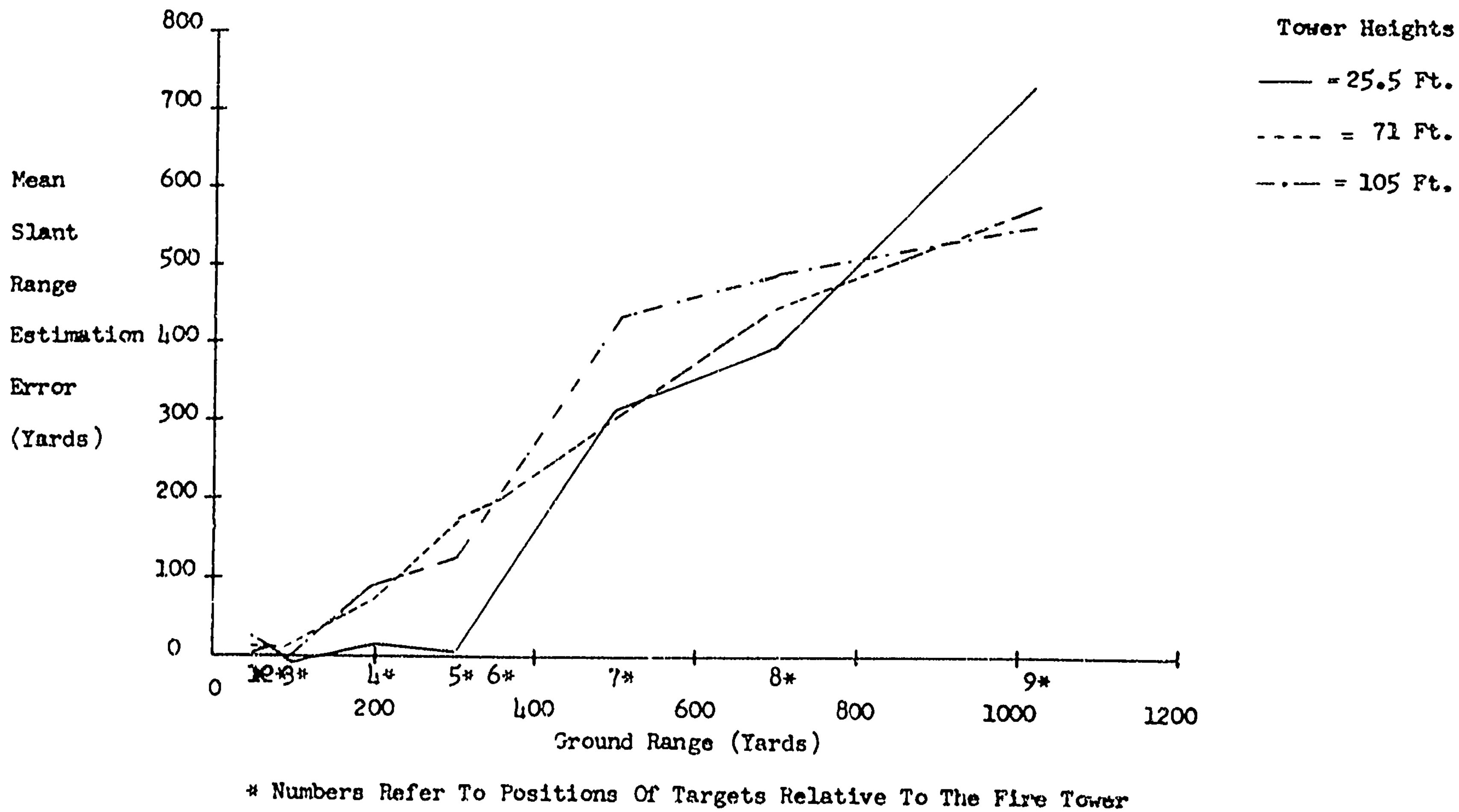
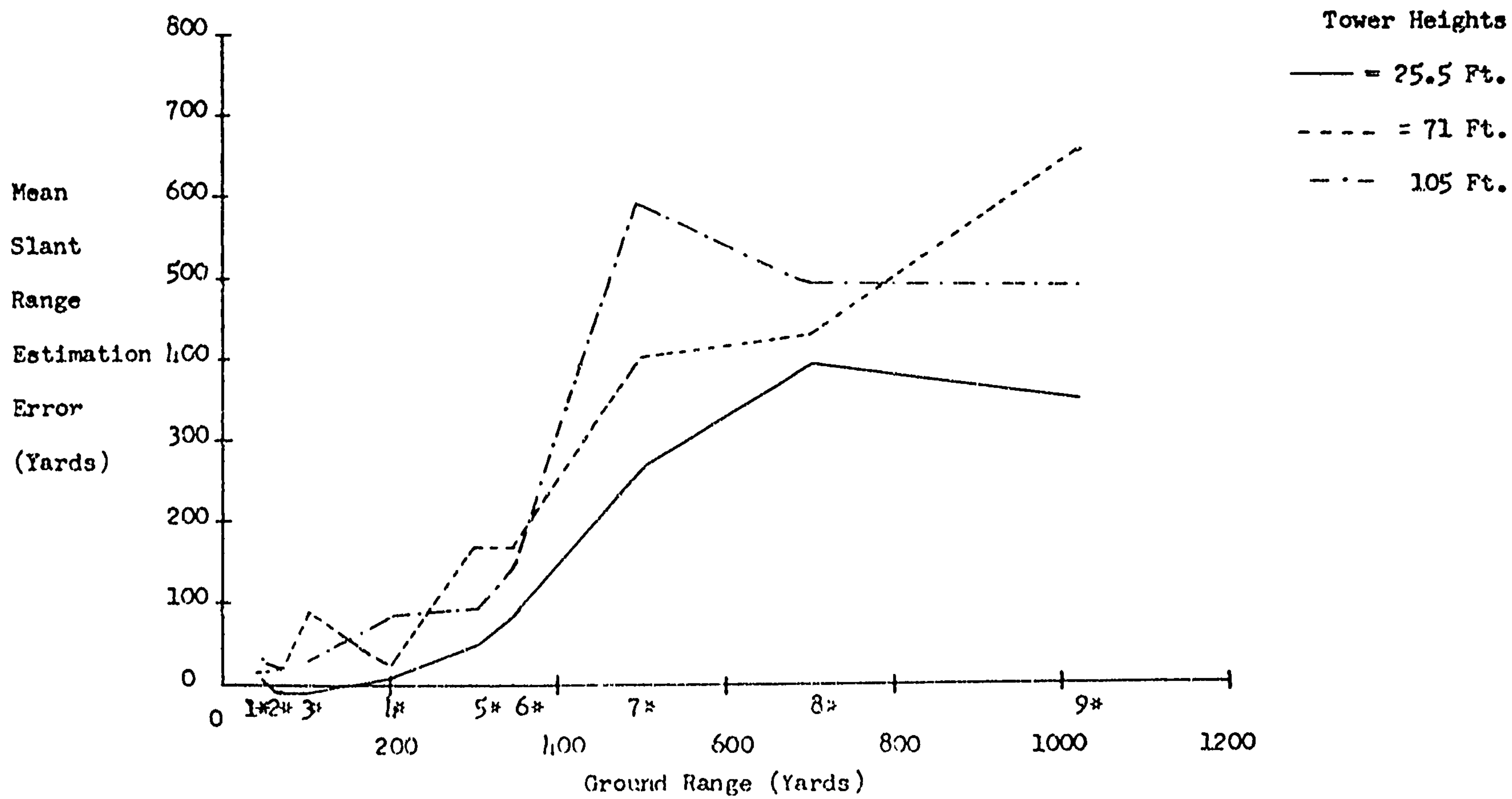
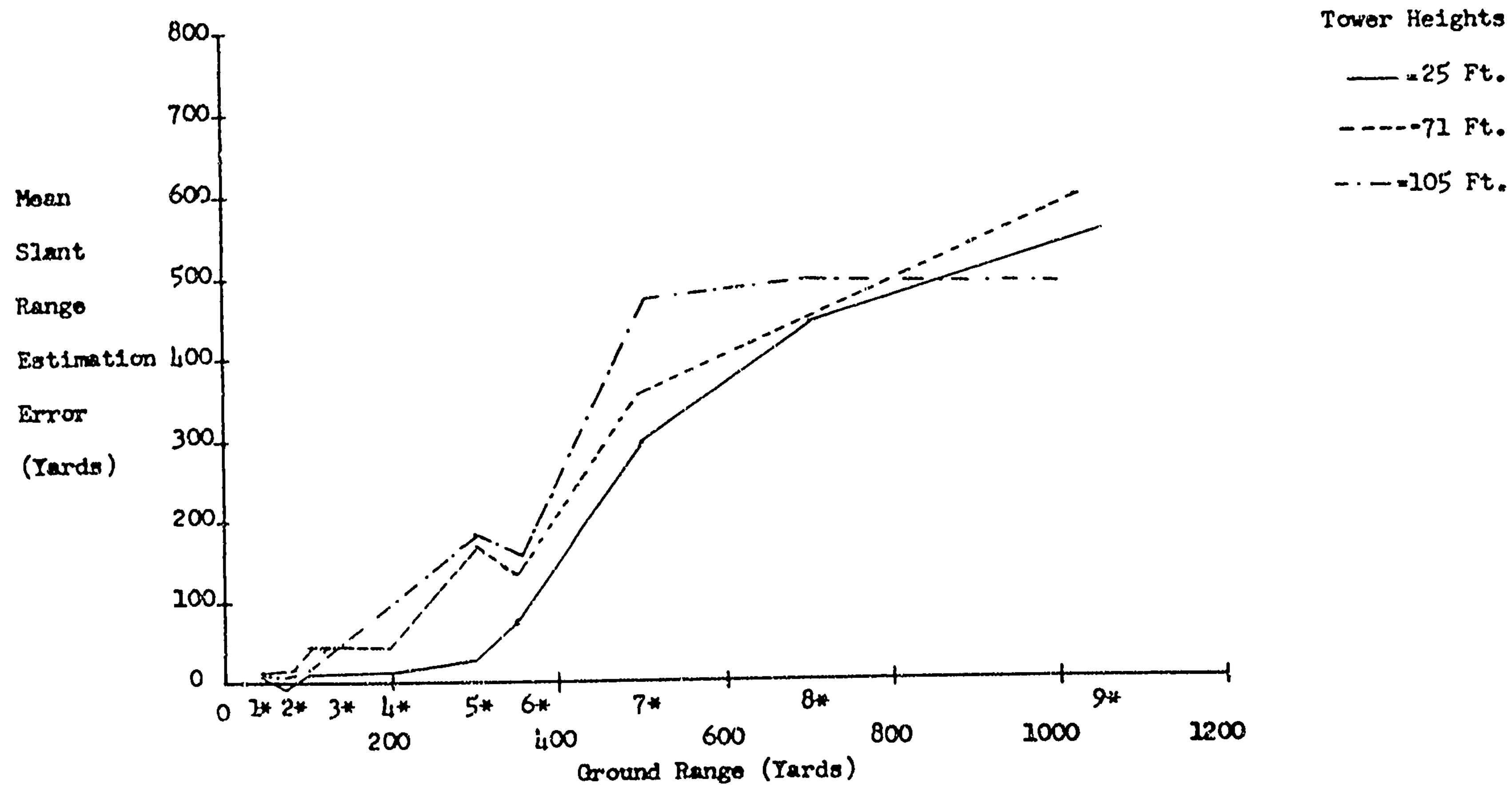


Fig. 7 - Mean Slant Range Estimation Error For 10 Seconds Of Observation



* Numbers Refer To Positions Of Targets Relative To The Fire Tower

Fig. 8 - Mean Slant Range Estimation Error For 20 Seconds Of Observation



* Numbers Refer To Positions Of Targets Relative To The Fire Tower

Fig. 9 - Mean Slant Range Estimation Error For Both 10 and 20 Seconds Of Observation

SUMMARY

A field test of unaided visual ranging from three fixed elevated platforms of 25.5, 71, and 105-feet was conducted at a site near Aberdeen Proving Ground, Maryland. This preliminary investigation was performed to form a baseline against which aids to ranging from an aerial platform could be compared. Nine distances from the tower, were selected for target positions. The ground range distances of the targets were 50, 75, 100, 200, 300, 350, 502, 702, and 1,102 yards.

Three independent variables were investigated - time to range on a target, altitude of observation, and range of target.

The two time intervals of 10 and 20 seconds did not differ significantly in accuracy of range estimation. Further reduction in time of exposure should be considered in future studies.

For the shorter ground ranges a slight but noticeable underestimation of distance from the lower observation altitudes was found, which is in accord with the findings of range estimations made on the ground. This negative error drops off as the altitude of observation is increased. For the intermediate ranges of 100 to 800 yards, the lowest altitude of 25.5 feet proved consistently superior, for the ranges of 800 to 1,100 yards the higher altitudes were superior.

After the shortest range intervals, the amount of range estimation error is an approximate linear function of ground range. It is in the neighborhood of 60 to 75% of ground range.